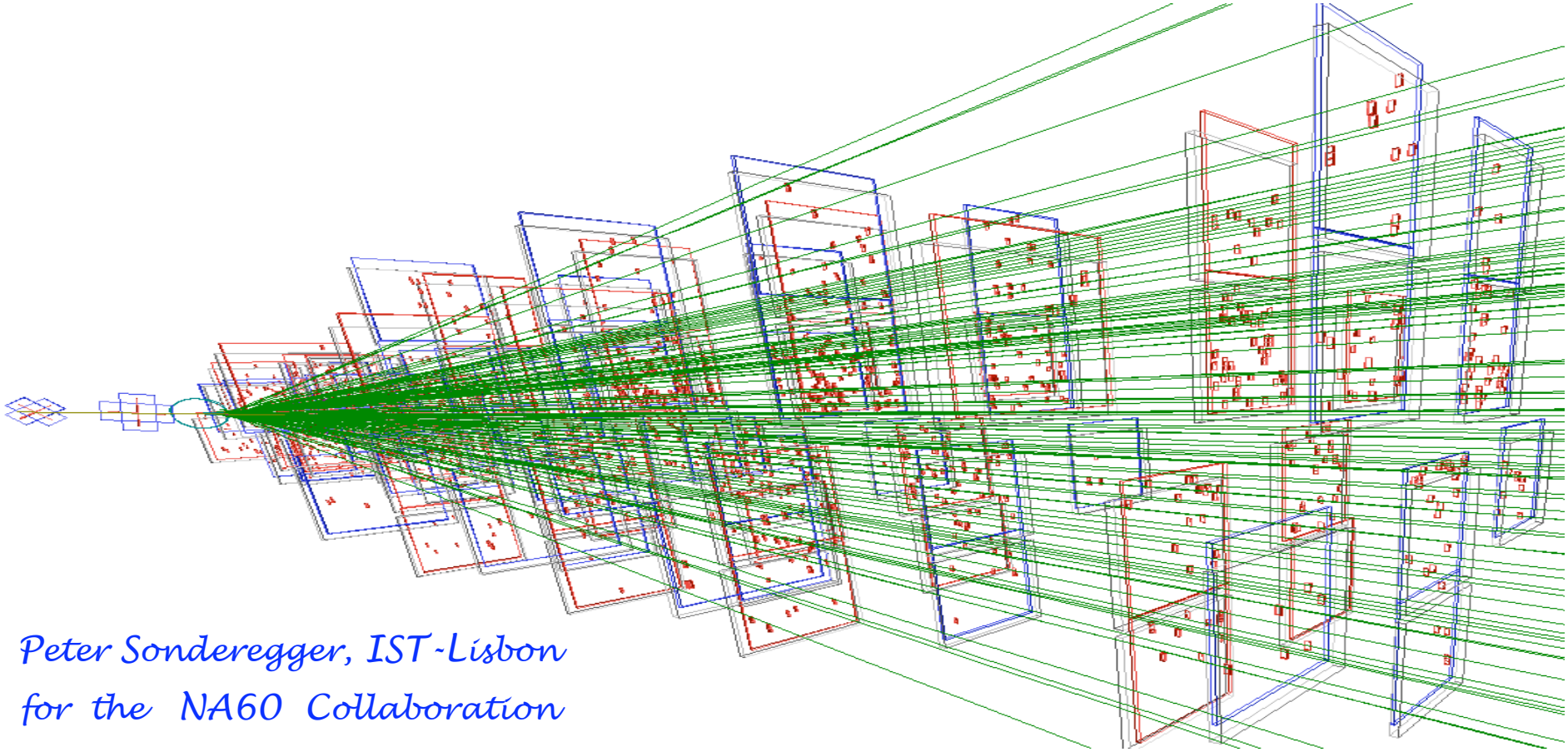
Accurate measurements of dimuon production in proton-nucleus and heavy-ion collisions: the NA60 experiment

- Overview of the physics motivation and detector concept
- News from the 2002 proton-nucleus and 2003 Indium-Indium runs



Peter Sonderegger, IST-Lisbon
for the NA60 Collaboration

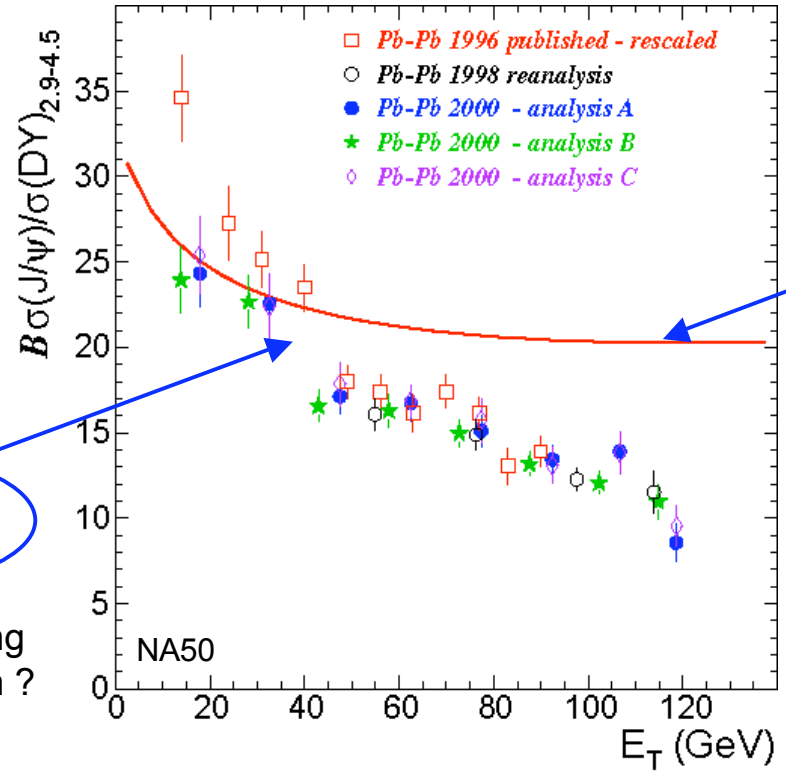
Questions left open by previous dilepton experiments

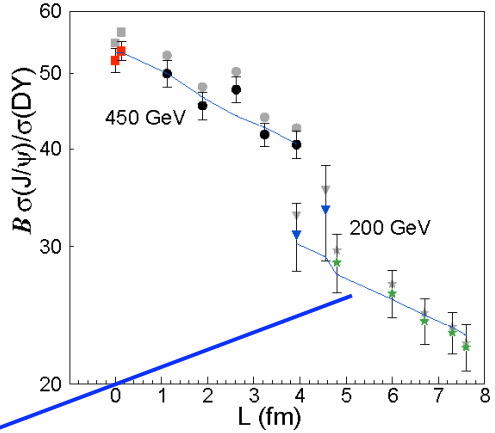
What physics variable rules J/ψ (χc ?) suppression ?

Energy density ? Number of participants ?

What fraction of J/ψ come from χc decays ? ≈ 30–40 % !

What is the nuclear dependence of χc production in p-A collisions ?





σ_{abs} = 4.3 ± 0.3 mb

J/ψ nuclear absorption

J/ψ or χc suppression ?

due to Debye screening
or to parton percolation ?

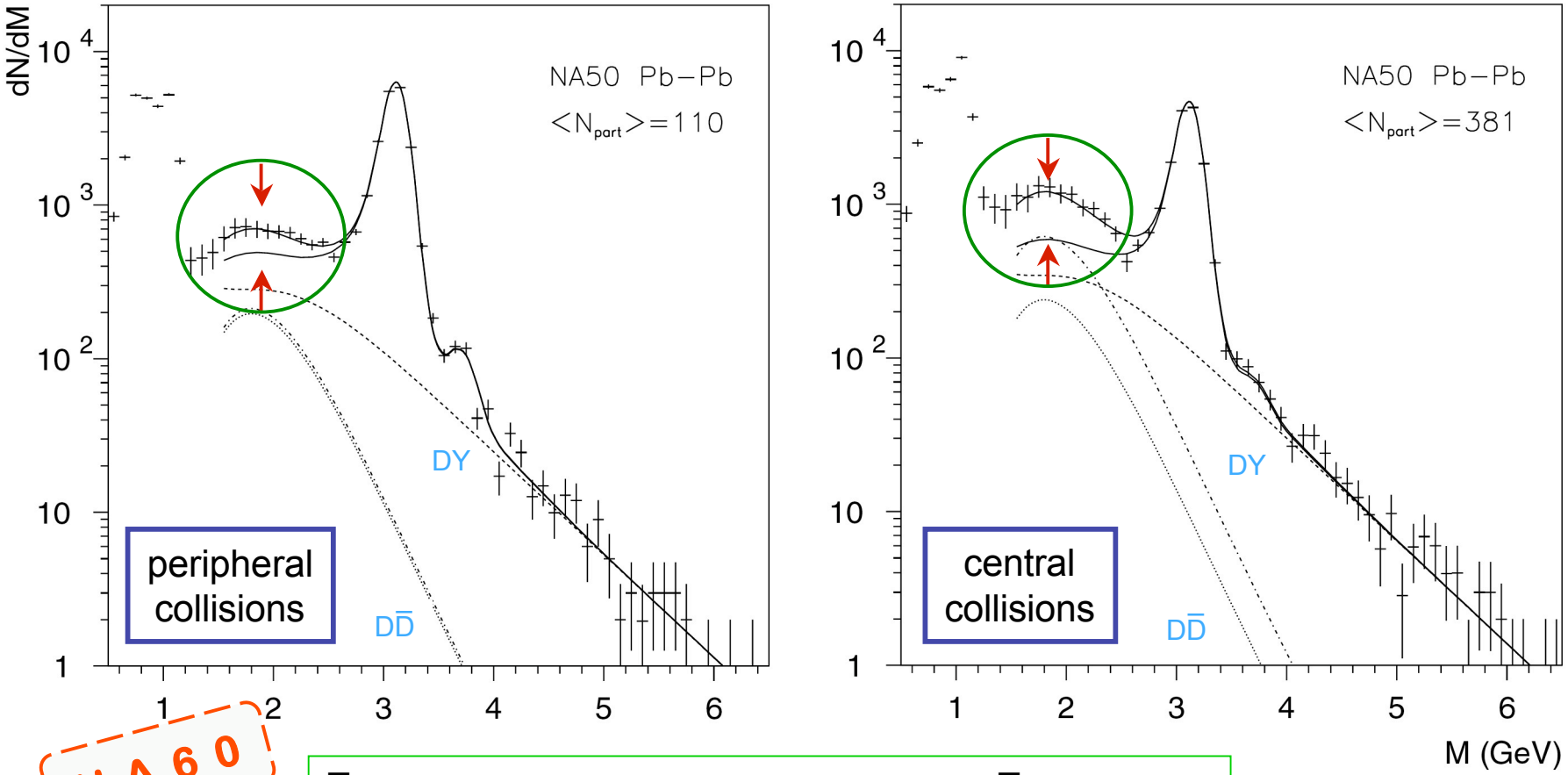
NA60

- Measure ψ' production in Indium-Indium collisions
- Measure χc production in p-A collisions

Questions left open by previous dilepton experiments

What causes the intermediate mass dimuon excess ? Thermal dimuons ?
Is the open charm yield enhanced in nucleus-nucleus collisions ?

In S-U and Pb-Pb collisions the yield of produced *intermediate mass* dimuons exceeds the superposition of the expected sources : Drell-Yan and D meson decays



NA60

Measure secondary vertices with 50 μm precision

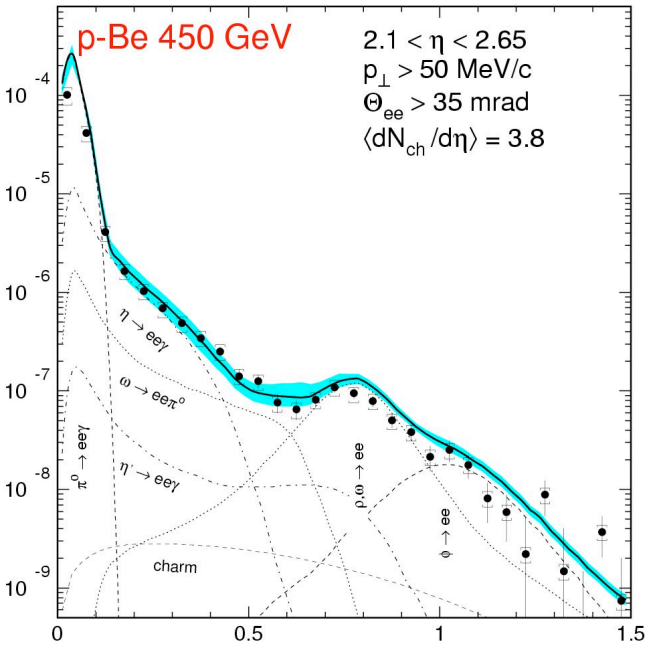
Questions left open by previous dilepton experiments

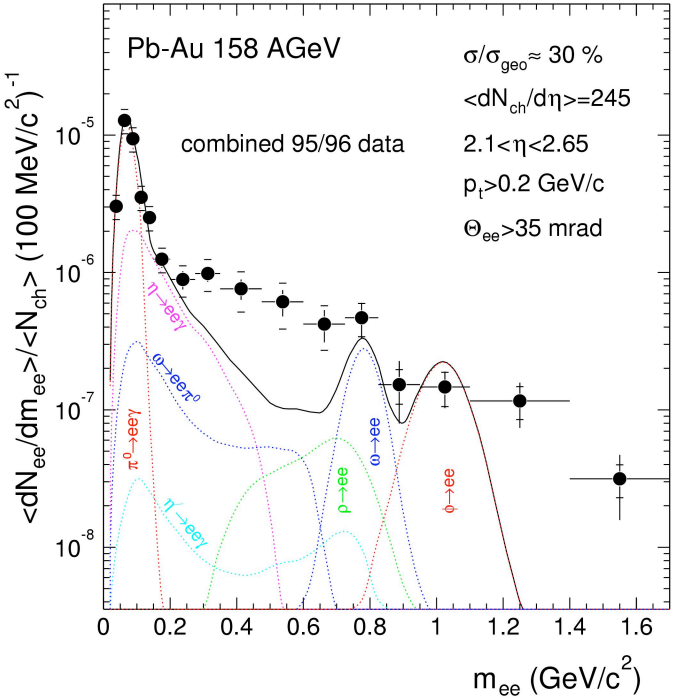
Is the □ meson modified by the medium ?

Short lifetime (□=1.4 fm/c) _ regeneration within medium for dilepton decay channels

Signal of chiral symmetry restoration ?

No □ visible in the heavy-ion CERES data

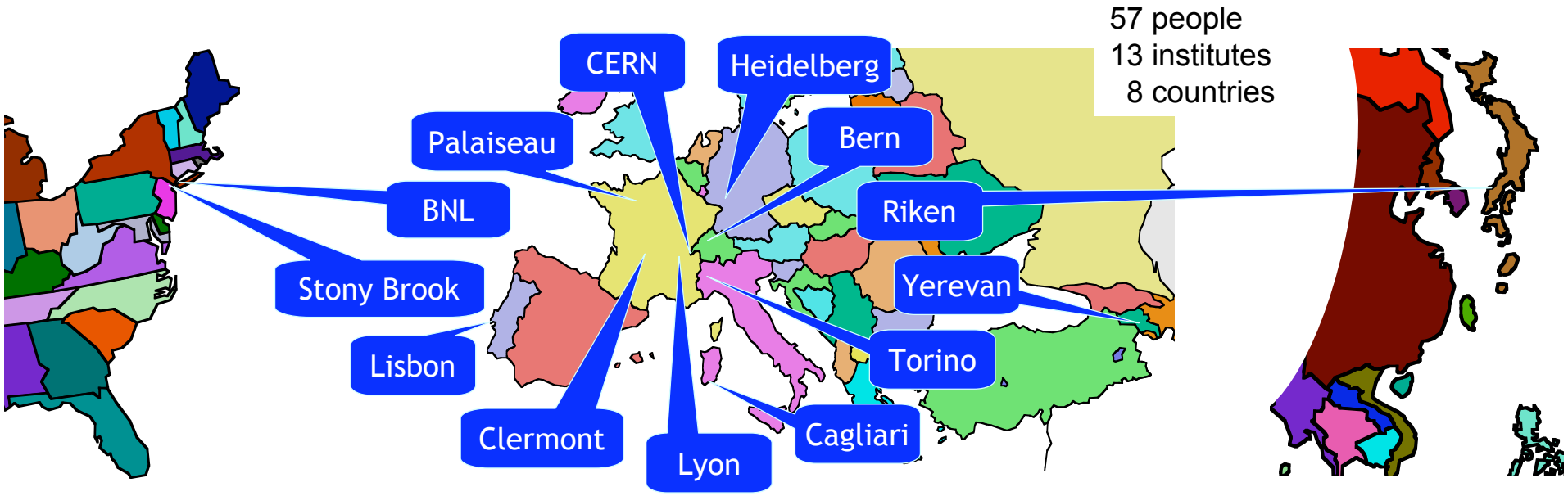




N A 6 0

- □ Much more statistics, thanks to a very selective dimuon trigger
- □ Better mass resolution and signal to background ratio
- □ Study the excess as a function of centrality

New and better measurements NA60

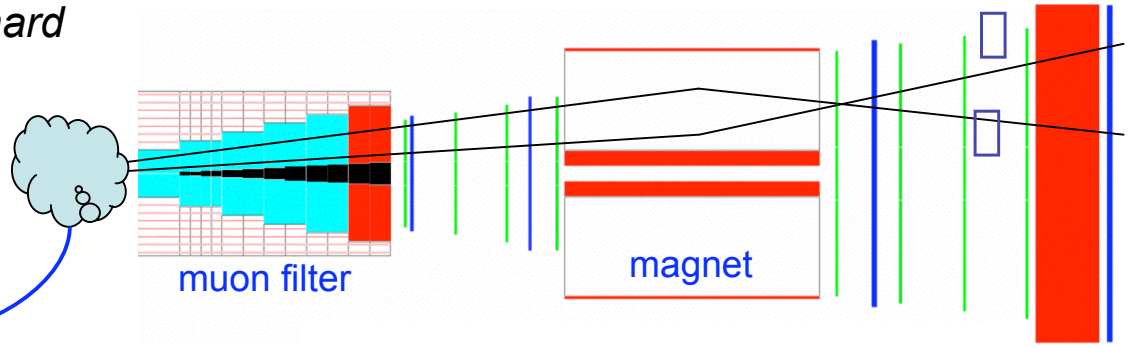


R. Arnaldi, R. Averbeck, K. Banicz, K. Borer, J. Buytaert, J. Castor, B. Chaurand, W. Chen, B. Cheynis, C. Cicalò, A. Colla, P. Cortese, S. Damjanovic, A. David, A. de Falco, N. de Marco, A. Devaux, A. Drees, L. Ducroux, H. En'yo, A. Ferretti, M. Floris, P. Force, A. Grigorian, J.Y. Grossiord, N. Guettet, A. Guichard, H. Gulkanian, J. Heuser, M. Keil, L. Kluberg, Z. Li, C. Lourenço, J. Lozano, F. Manso, P. Martins, A. Masoni, A. Neves, H. Ohnishi, C. Oppedisano, P. Parracho, G. Puddu, E. Radermacher, P. Ramalhete, P. Rosinsky, E. Scomparin, J. Seixas, S. Serci, R. Shahoyan, P. Sonderegger, H.J. Specht, R. Tieulent, G. Usai, H. Vardanyan, R. Veenhof, D. Walker and H. Wöhri

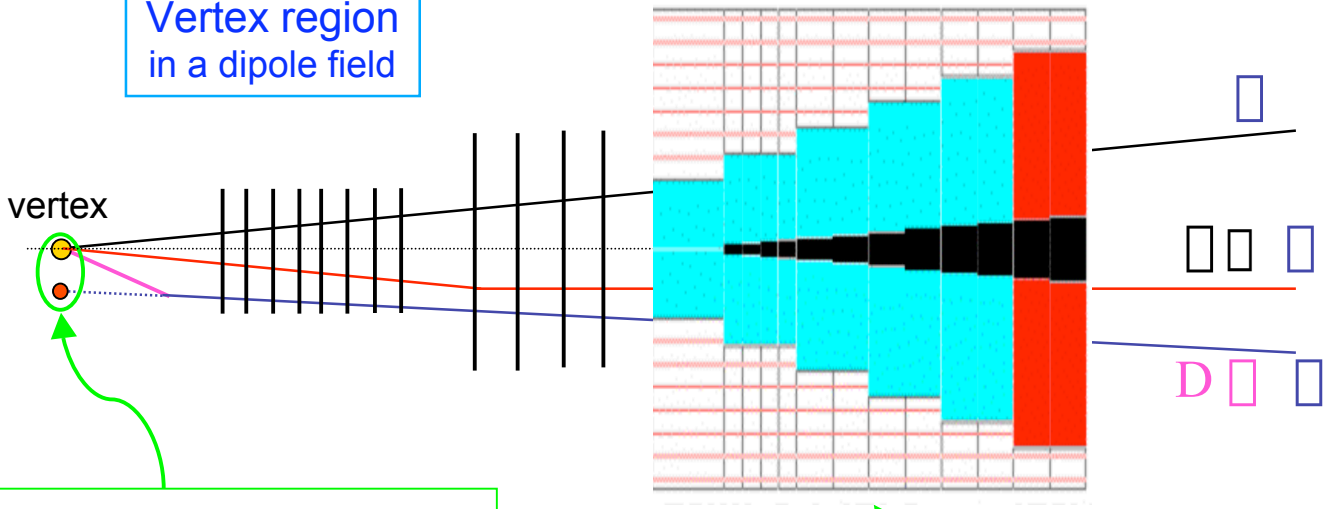
From the NA60 detector concept …

Place a *high granularity* and *radiation-hard* silicon tracking telescope in the vertex region to measure the muons before they suffer multiple scattering and energy loss in the hadron absorber

Muon spectrometer (from NA50)



Vertex region
in a dipole field

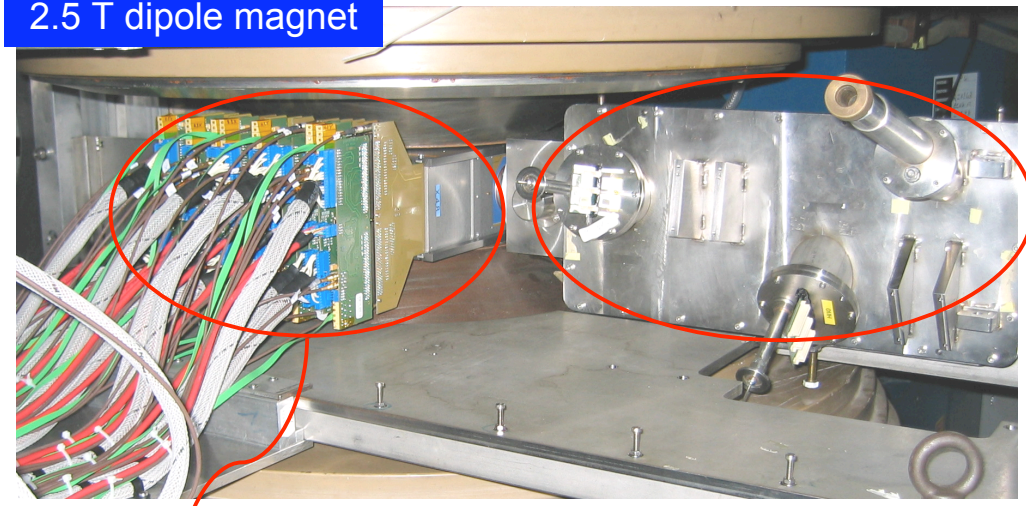


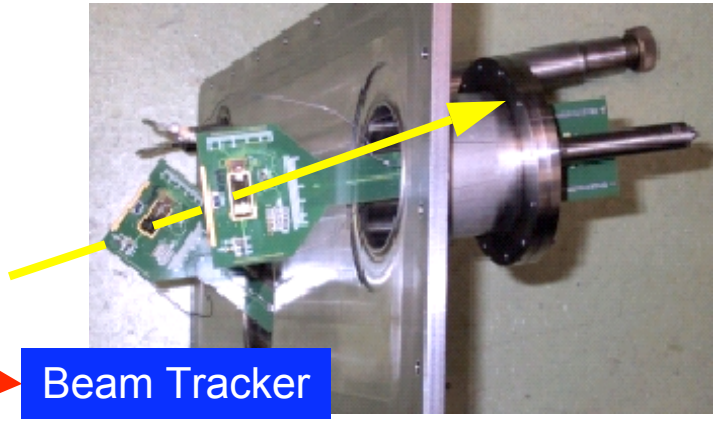
Muon track offset measurement :
Separate **charm meson decays** from **prompt dimuons**

Muon track matching through the absorber :
Improved **mass resolution** and **signal / noise**

… to the reality of the new vertex region

2.5 T dipole magnet

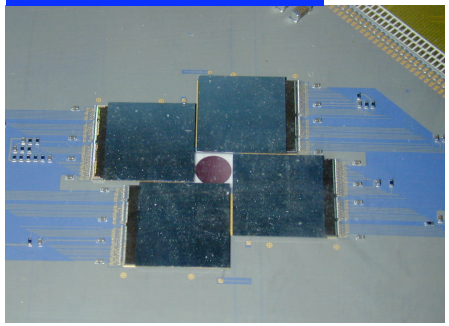


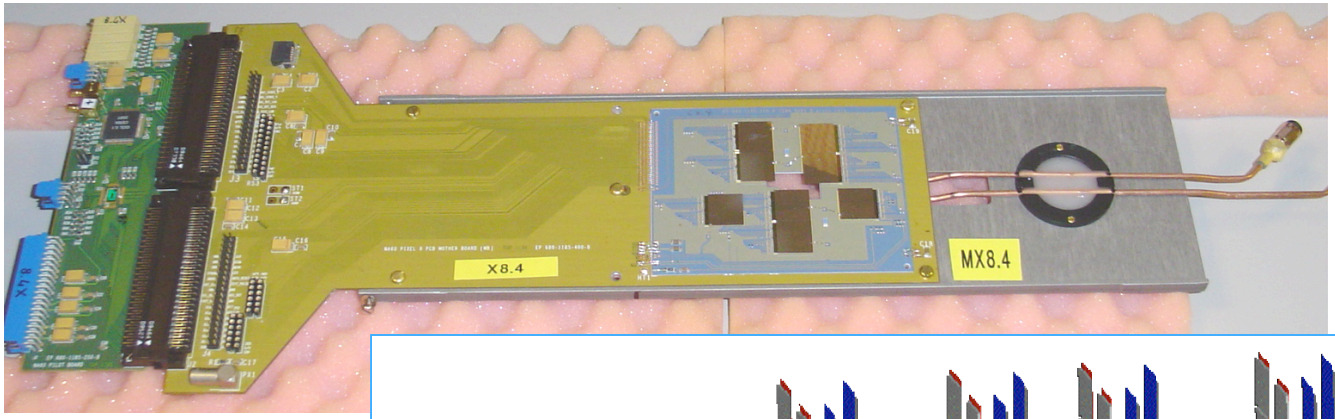


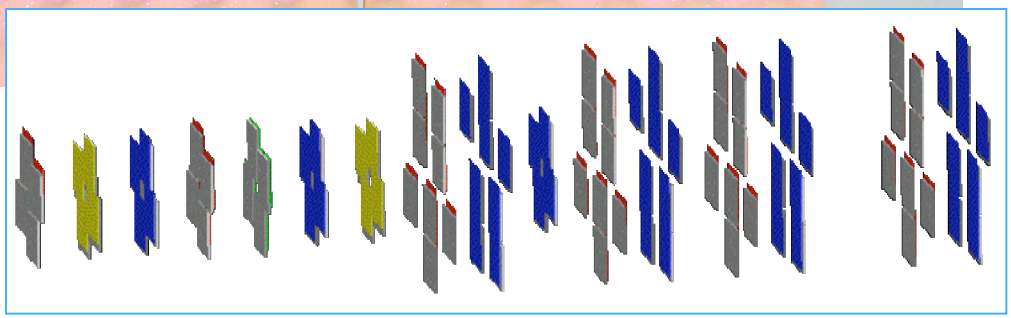
Beam Tracker

- Two stations of back-to-back micro-strip sensors with 24 strips of 50 □m pitch
- 20 □m resolution on the transverse coordinates of the interaction point
- Operated at 130 K □ radiation hardness

Pixel planes

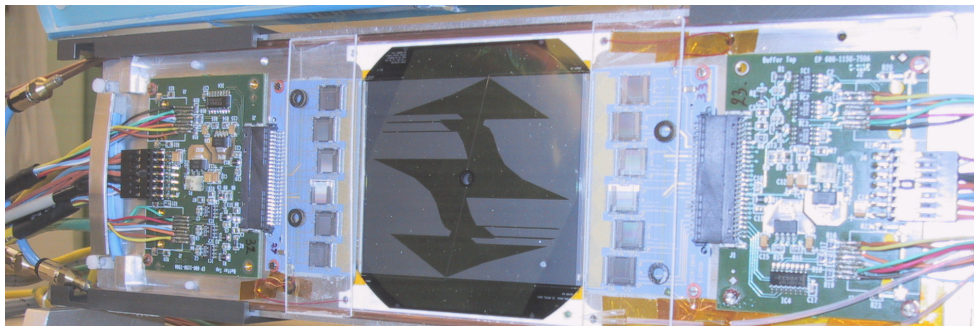




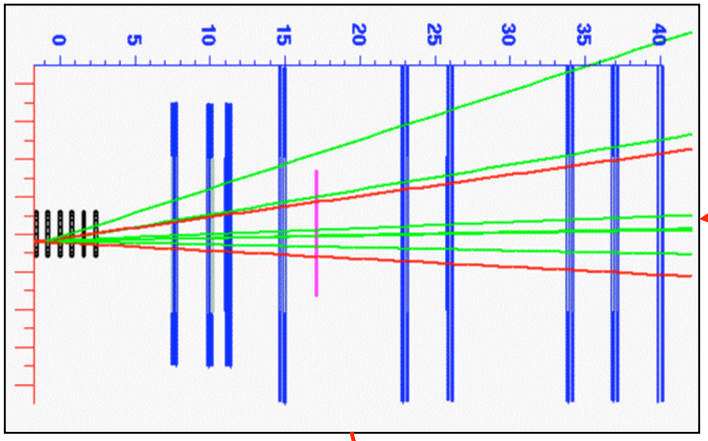


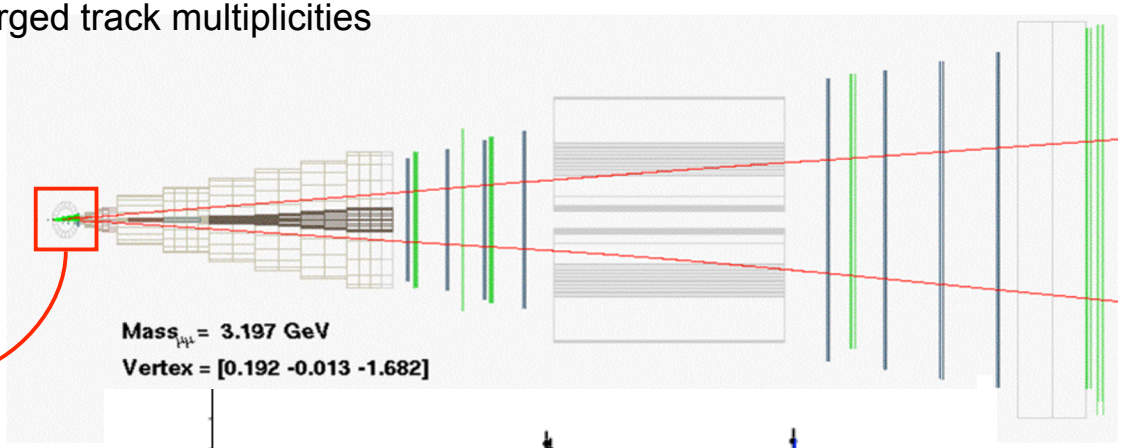
- 8 planes of 4 chips plus 8 planes of 8 chips □ good acceptance, 11 tracking points
- Each chip = 8192 cells of 50 × 425 □m^2
- ALICE1LHCB read-out chips, 10 MHz clock

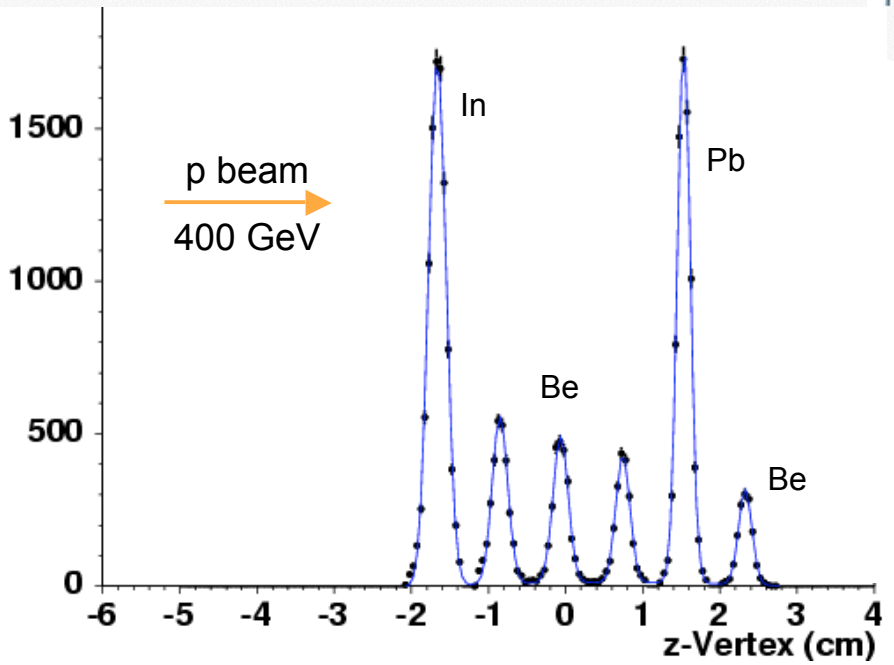
June 2002 proton-nucleus run



- 14 micro-strip tracking planes (and a pixel plane)
- 12×128 strips per sensor, from 60 to 227 μm pitch
- Good enough granularity for p-nucleus charged track multiplicities



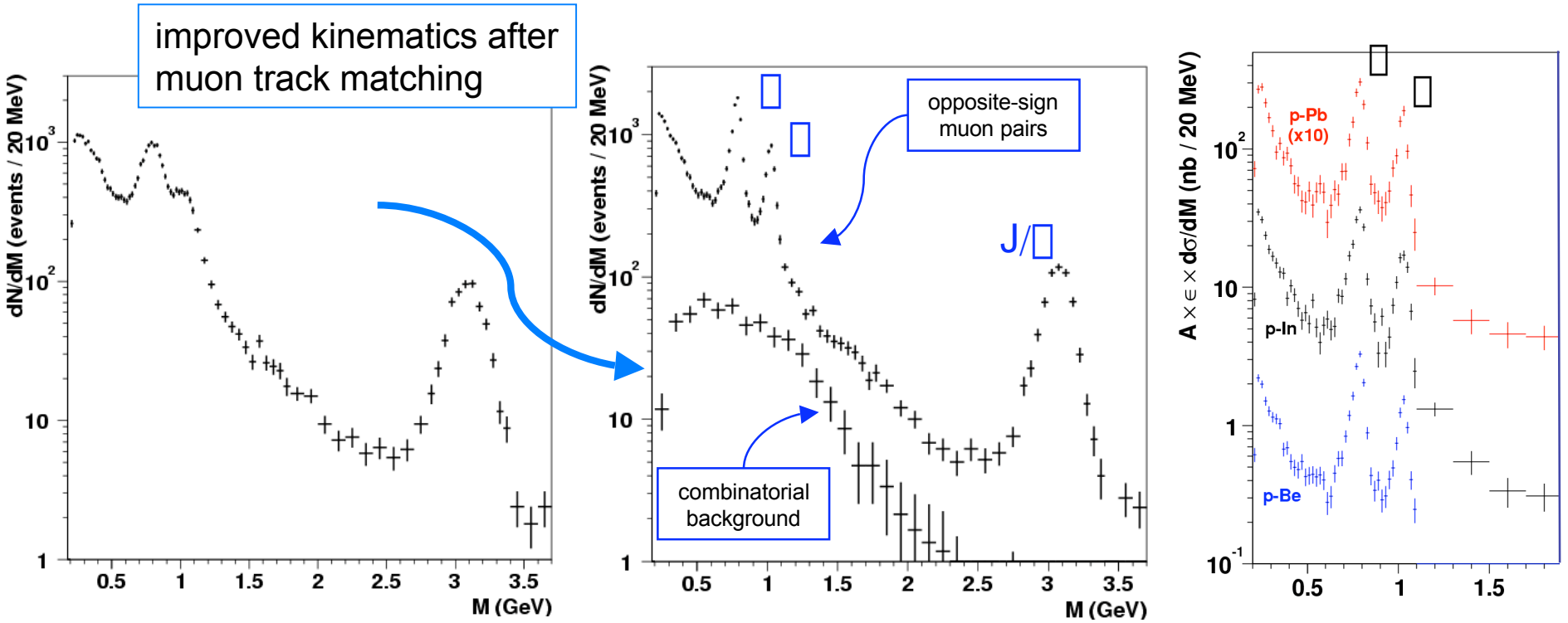




- Z-vertex resolution ~ 600–900 μm
- 2 mm thick targets clearly separated

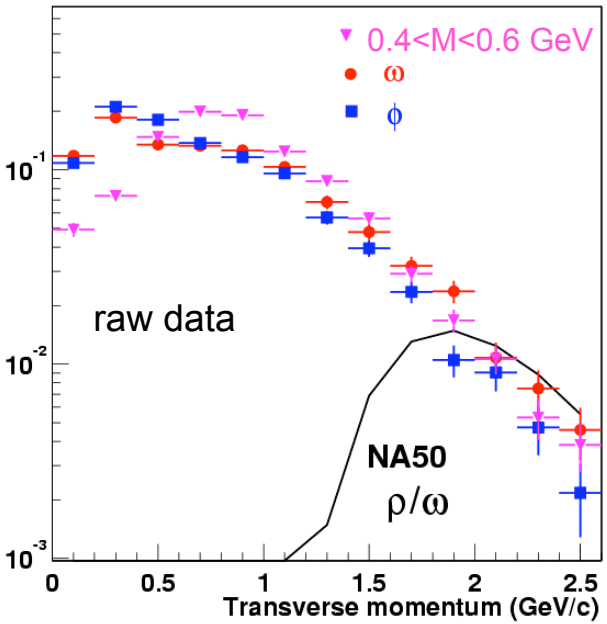
June 2002 run: statistics and dimuon mass resolutions

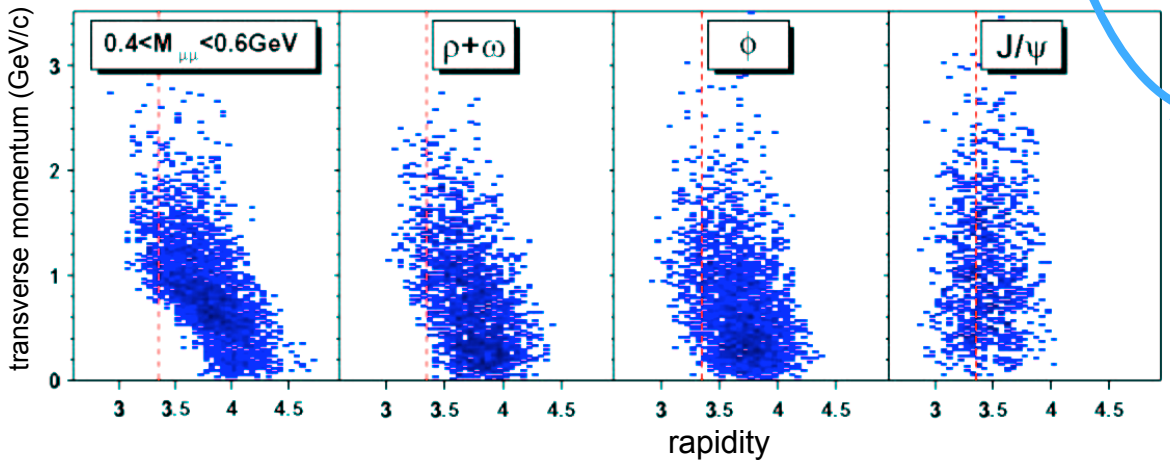
- Data collected in 4 days, at a beam intensity of ~ 2□10^8 p/burst
- After matching and vertex selection cuts ~ 25 000 dimuons are left
- Like-sign / opposite-sign : ~ 25% □ ~ 7% after matching
- Mass resolution in the □/□ mass region : ~ 70 MeV (NA50) □ 25–30 MeV ;
  and in the J/□ peak : 125 MeV (NA50) □ 90 MeV



Dimuon phase space coverage

- Much better p_T coverage for low mass dimuons than NA38 / NA50 due to dipole field in target region

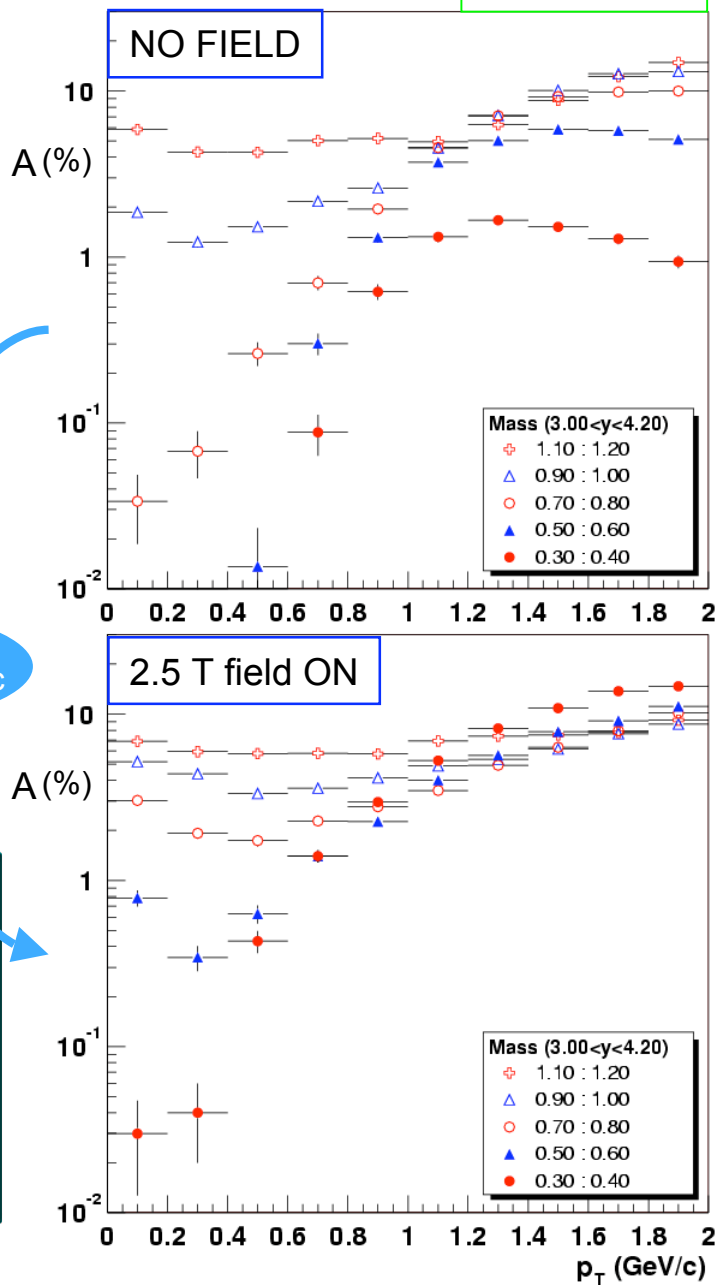




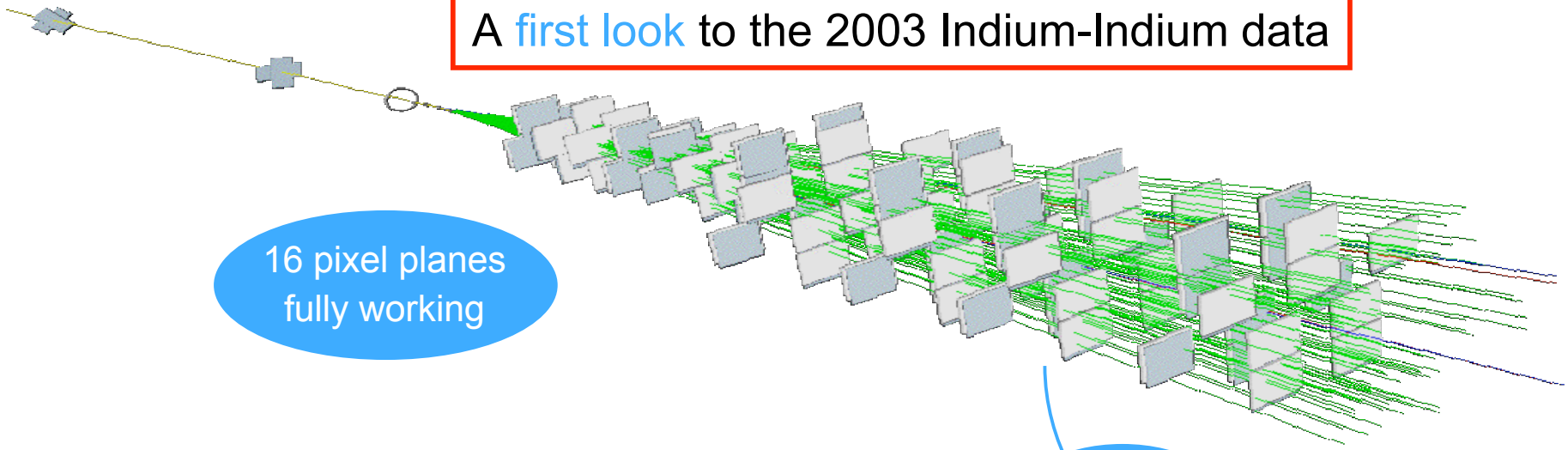
Acceptance improves in all M and p_T windows

by a factor 50 for M ~ 500 MeV and p_T ~ 500 MeV/c

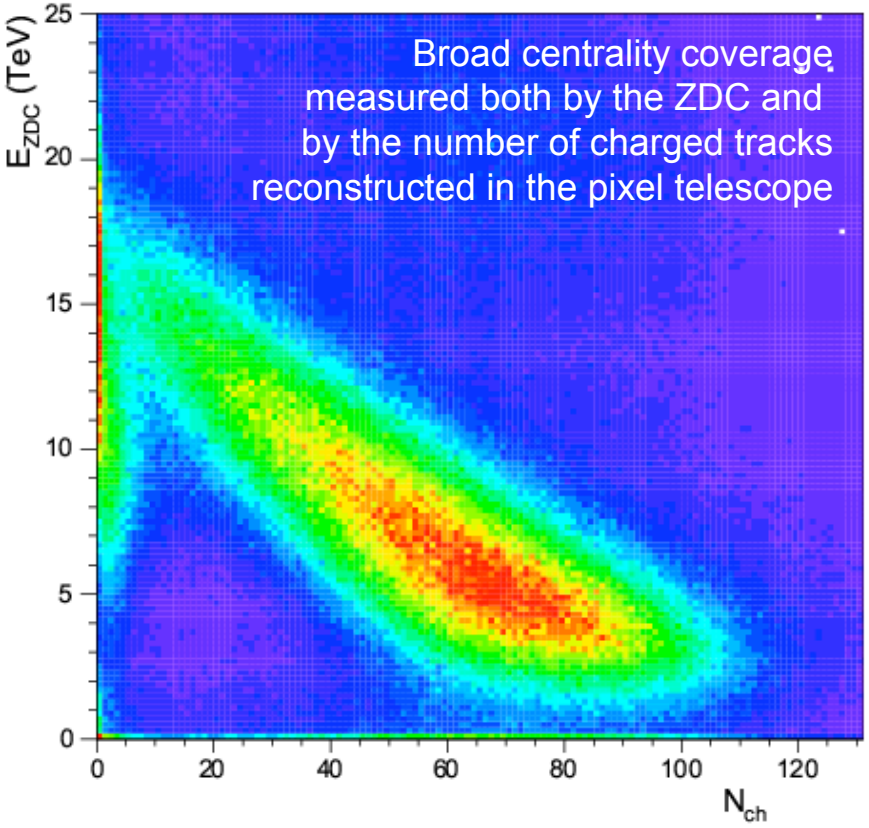
Monte-Carlo



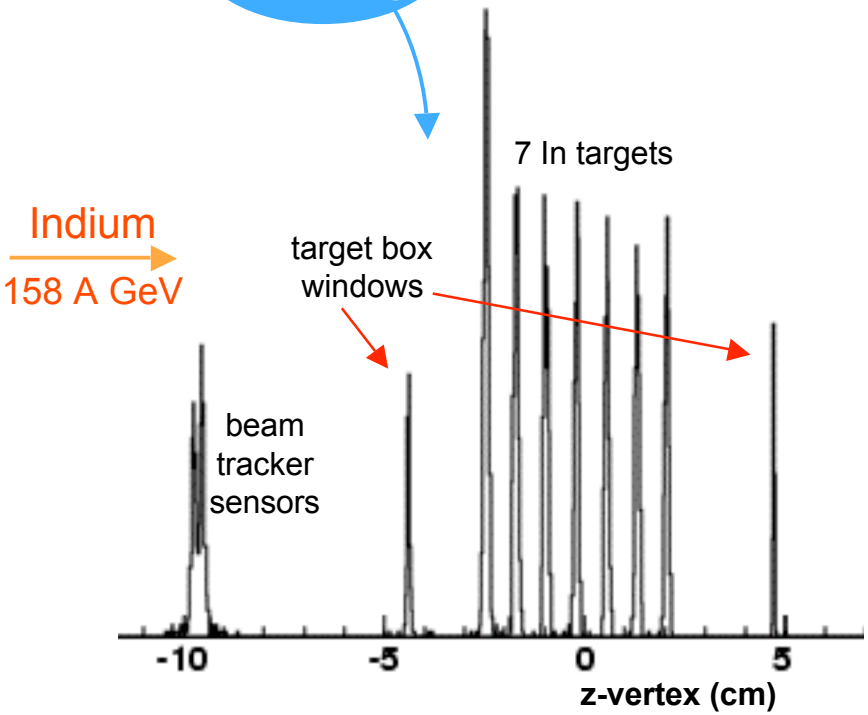
A first look to the 2003 Indium-Indium data



16 pixel planes fully working

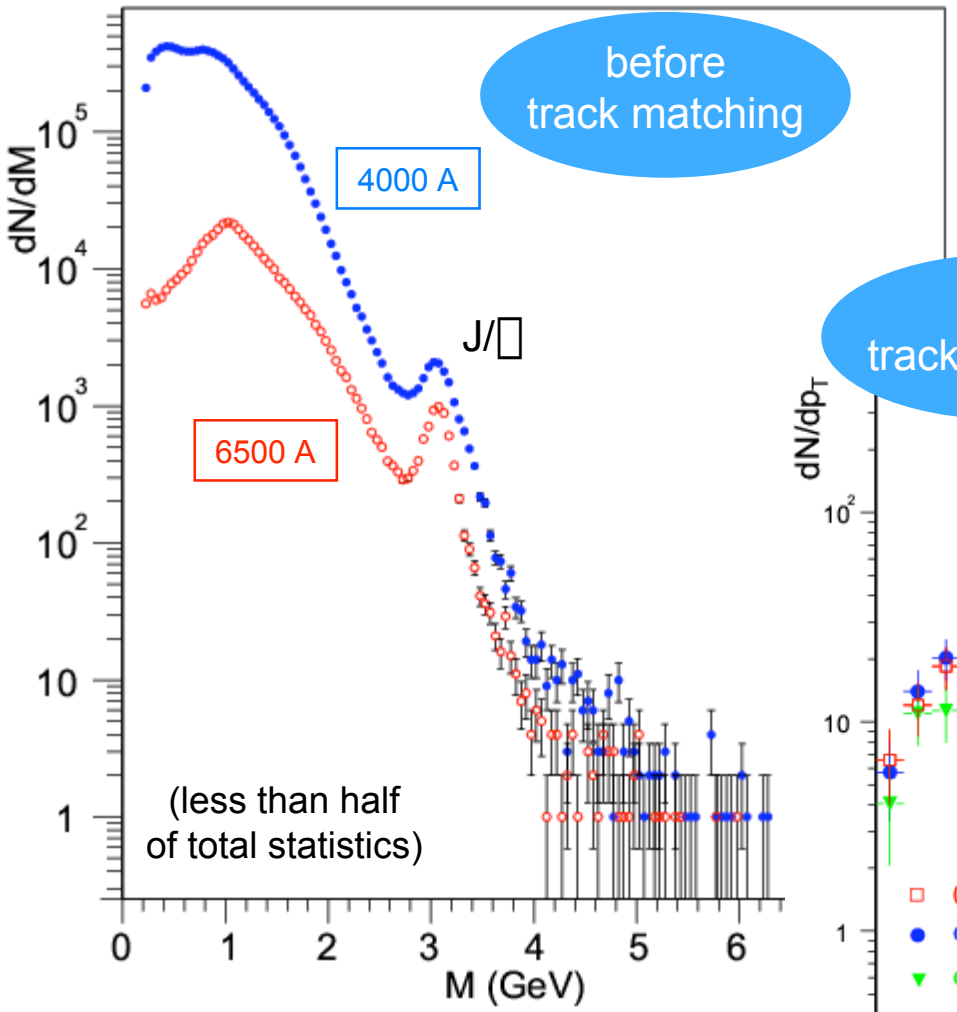


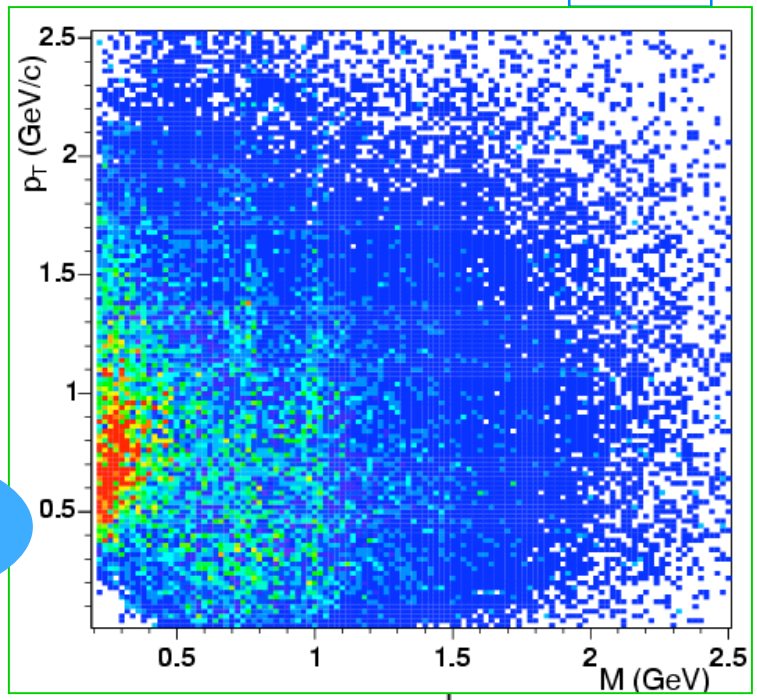
good vertexing



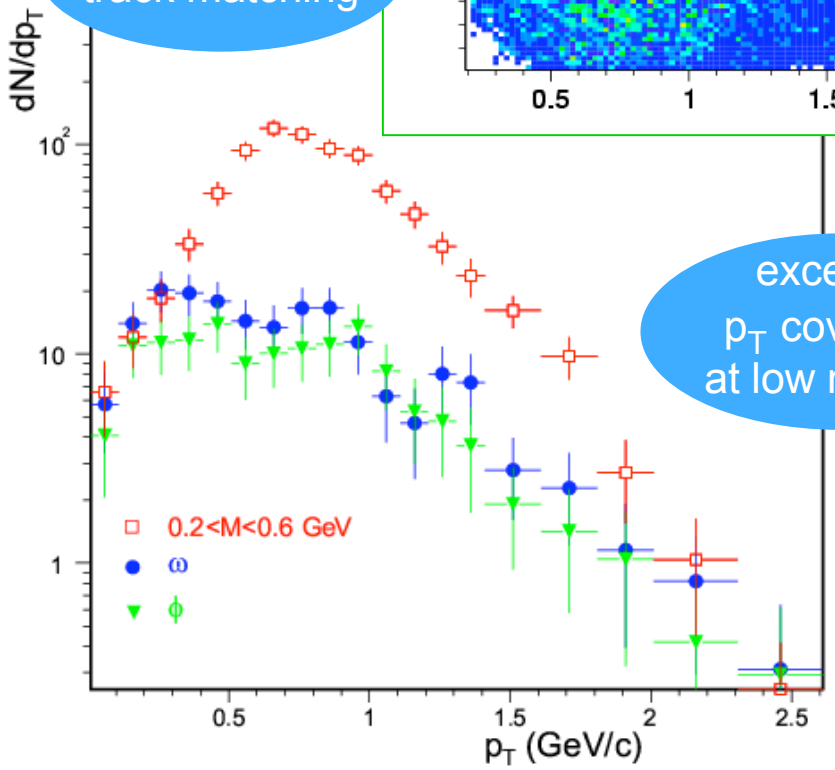
Dimuons from Indium-Indium collisions

Data collected with two different currents
in the spectrometer's magnet





after
track matching

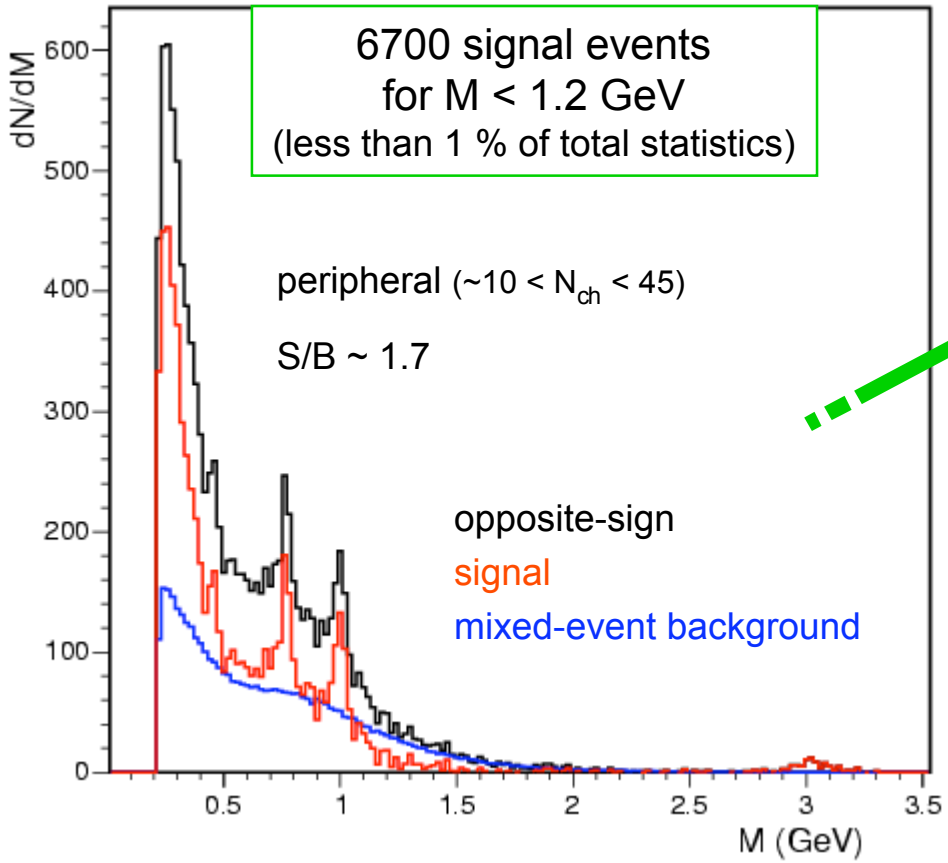


excellent
p_T coverage
at low masses

Dimuons from Indium-Indium collisions

mass resolution :
~ 20 MeV at M ~ 1 GeV

… from a very fast analysis of
a very small event sample …

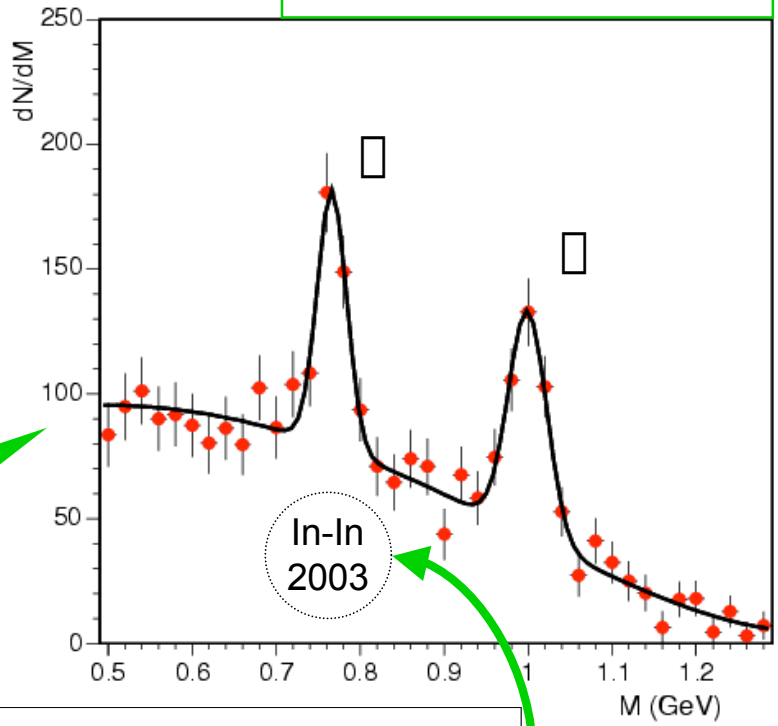


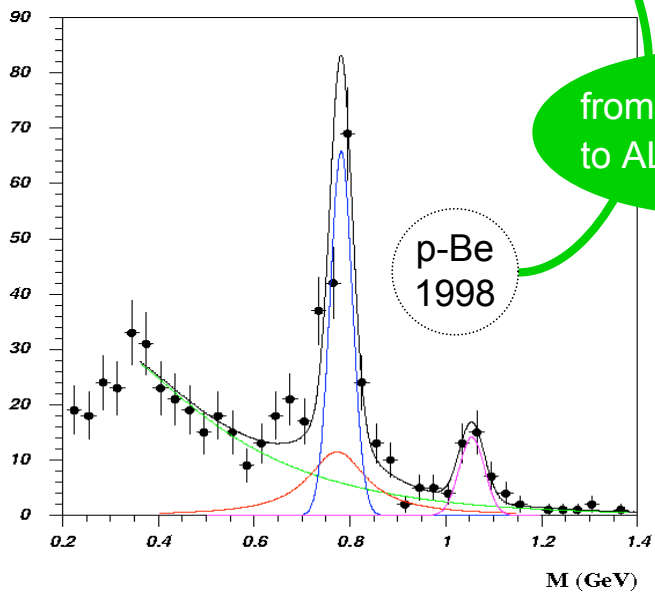
6700 signal events
for M < 1.2 GeV
(less than 1 % of total statistics)

peripheral (~10 < N_{ch} < 45)

S/B ~ 1.7

opposite-sign
signal
mixed-event background





from WA97 pixels
to ALICE pixels…

> 100 000 □_□□ decays from the full data sample

□_K^+K^- decays also under analysis

Summary and outlook

- Long “learning curve” from 1979 (NA10) to radiation-tolerant pixels in dimuon physics
- Harvest from the 5-week long Indium run in Oct.–Nov. 2003 :
  - ✓ more than 100 000 reconstructed J/ events (before matching)
  - ✓ ~ 1 million signal low mass dimuons (after matching)
  - ✓ mass resolution ~ 20 MeV at the and masses
  - ✓ low mass signal to background ratio around 1:1 or 1:2 depending on centrality (a factor 4 better than before muon track matching)

Together with the 80-days long proton run of 2004, NA60 should be able to clarify :

- the cause of the excess of intermediate mass dimuons :
  - ✓ thermal dimuons from a QGP phase or open charm enhancement
- the production and suppression of charmonium states
  - ✓ including the nuclear dependence of $_c$ production
- the production of low mass dimuons, including the , and resonances :
  - ✓ with very good statistics, mass resolution and signal to background ratio
  - ✓ with good phase space coverage, down to zero p_T
  - ✓ with a detailed study of charged multiplicity dependences

- Theory predictions are needed now, before final Indium-Indium physics results are shown